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STRATEGY OF REGENERATION AFTER FIRE IN THE FOREST AREA OF WESTERN ALGERIA

Borsali Amine Habib, PhD
University "Dr. Moulay Tahar"/ Saida and University of Tlemcen, Algeria
Benabdeli Kheloufi, Prof.
University of Mascara / Geo-environment and development of spaces, laboratory Faculty of science and life, Algeria
Gros Raphael, PhD
Aix-Marseille University/ Mediterranean Institute of biodiversity and ecology, Faculty of sciences and technology of Saint-Jérôme, France

Abstract

The objectives of this study were of even the effects of the recurrent fires on the regeneration strategy postfire plant groupings Pinus halepensis in the Saida region (Western Algeria).Indeed, many Mediterranean species have adopted strategies of regeneration to survive fires. For that we have chosen the forest of Fenouane (Wilaya of Saïda) located in the bioclimatic floor semi arid to analyze the effect of fire on vegetation regime. This region of Algeria is marked by an important arid with higher maximum temperatures and dry a wide period this year representing a preponderant factor of the departures of fires. The results reveal a regeneration of vegetation 4 years after fire and essentially by semi mainly due to the presence in our study site of species which regenerate by seed germination. The results also show that repeated fires lead to a marked floristic depletion and burned vegetation mainly evolved maquis highlighting the intensity of the fire regime and threatening long-term pine forests. It appears from this study that fire reduces diversity and density of forest stands. The pine of Aleppo Cistus, Calycotome are mainly the only forest species that developing after fire. Resistance skills relate to their morphology and the intensity of the fire regime.

Keywords: Regeneration, fire, Pinus halepensis, Semi - arid, Saida (Western Algeria)

Résumé

Les objectifs de cette étude étaient de voire les effets des incendies récurrents sur la stratégie de régénération après un feu des groupements

végétaux *Pinus halepensis* dans la région de Saida (ouest algérien). En effet, beaucoup d'espèces méditerranéennes ont adopté des stratégies de régénération leur permettant de survivre aux incendies. Pour cela nous avons choisie la Forêt de Fenouane (Wilaya de Saida) située dans l'étage bioclimatique semi aride pour analyser l'effet du régime de feu sur la végétation. Cette région d'Algérie est marquée par une aridité importante avec des températures maximales élevées et une large période sèche au cours de l'année représentant un facteur prépondérant des départs des feux. Les résultats révèlent une régénération de la végétation 4 ans après le feu et essentiellement par semi principalement due à la présence dans notre site d'étude d'espèces qui se régénèrent par la germination des graines. Les résultats montrent aussi que des feux répétés conduisent à un appauvrissement floristique marqué et la végétation incendiée évolue principalement vers des maquis accentuant l'intensité du régime d'incendie, et menaçant à long terme les pinèdes. Il ressort de cette étude que le feu diminue la diversité et la densité des peuplements forestiers. Le Pin d'Alep Ciste, Calycotome sont principalement les seules espèces forestière qui se développant après feu. Leurs capacités de résistance sont liées à leur morphologie et à l'intensité du régime de feu.

Mots clés : Régénération, Incendie, *Pinus halepensis*,Semi –aride, Saida (Algérie occidentale)

Introduction

Algerian forests constitute an exceptional diversity of ecological systems and biodiversity that they incorporate. According to the Directorate General of forests, on a forest heritage of 4.7 million hectares forests say economic and likely production in Algeria barely cover 1.3 million hectares. The major cause of the loss of forest area remains fires and desertification (Le Houérou, 1973). Fires destroy averaged more than 36 000 ha of woody trainings a year. This study is directly inspired by the expectations for strategy of reforestation, management and sustainable development of Algerian forest resources of the Directorate General of forests in particular semi arid and arid zones undergoing in addition to very specific climatic risks which predominate in these areas, the fires that destroyed several hectares of forest every year. The objectives of this strategy are to limit the risks of fires, to contribute to the fight against desertification and perpetuate forest productions by a reasoned choice of species that have the capacity to adapt to these particular environments. The mastery of techniques for the study of the vegetation and to know the species that are the more resistant to climatic constraints and fire is a necessary prerequisite for the assessment of the vulnerability of forests from semi-arid to fire.

Algerian forests appear to slip inexorably towards a progressive degradation and their replacement by Garrigue and maquis, given their histories and incendiary pressures being exerted constantly on them (Benabdeli, 1996).

Degraded stages from which the reconstructions spontaneous or assisted forest stands are very difficult. The sustainable management of these areas must therefore be informed by a species assessment that better resist fire under an accelerated procedure of aridification. It also requires the development of simple, inexpensive and effective tools enabling the creation of a database of species the better adapt to these areas and the most resistant and a delimitation of areas of priority fighting fires or for the decision support to achieve development and forest reforestation necessarily evolutionary and adaptive.

The originality of our study lies in the forest it has chosen for or even that they are plant species that remain in these areas and their regeneration strategy against fire in particular climatic conditions, in fact the study area is located in the forest of Fenouane (Sidi M'Barek, Wilaya of Saïda, Algeria). At the level of these areas arid semi in a normal context out of fire, the vegetation is in continual struggle against the harsh climate and a very poor soil nutrient and organic matter. The passage of a fire even low translates directly into the alteration of the vital organs of the plant, at the level of the foliage, trunk and roots, it follows a loss of vigor of trees that may cause their death. Repeated fires lead to a marked floristic depletion. Many plants did not have time to reach sexual maturity before the passage of a new fire. Species capable of dissemination and resistance to high heat (Cistus, Calycotome) then constitute the bulk of the vegetation cover in these areas. The knowledge of the mechanisms of natural regeneration of trees forest is fundamental to understand the evolution of the floristic composition after fire. The mechanisms of regeneration of tree species in pure stands, have been the subject of numerous studies, and are relatively well understood. On the other hand, the behavior of mixed stands was not often explored, and possible interactions between different species at the time of the recolonization of the burned territory are at present still little known.

The objective of this study is to evaluate, for the forest region of Fenouane quite representative of the forest formations of the semi-arid floor affected by a resurgence of fires and faced with difficulties of afforestation, the impact of fire on vegetation by identifying and analyzing the main types of strategies of regenerative mode of fire. Indeed, many Mediterranean species have adopted strategies to survive fire and our study aims to show that they are the regeneration strategies more than adopt arid areas. To meet this goal, 25 forest stations in the forest of Fenouane (Saida mountains) have been selected on the basis of specific dates of fires. These geo-referenced

stations allow to study in climate, forest and geological conditions homogeneous and known, vegetation of a chrono-sequence of 2, 4, 8, 13 and 20 years after the last fire.

Materials and Methods

Presentation of the study area

The forest of Fenouane (Picture 1) is located in the southern foothills of the tellian atlas about 30 km of the wilaya of Saïda; its average altitude is 850 m. two exhibitions are distinct in the forest: one of the ver West East and across the South East Ver the North West. It is characterized by a significant heterogeneity topographic and floristic, representative groups dominated by Aleppo Pine and Cedar L'oranie thermophilic with however a remarkable Brushy undergrowth which plays a significant role in the regeneration of the Aleppo Pine and the mitigation of the effects of the course. Incorporated based essentially training tree and shrub species very drought-tolerant and strong ability to reject (BNEF, 1990).

Picture 1: Fenouane forest (Borsali, 2010)

Choice of the chronosequence post fire

The choice of observation sites (figure 1) was imposed by areas where fires themselves are repeated, therefore directed sampling. Plots, depending on the number of fires they have suffered in 20 years (lack of sales beyond this range) were selected. A repository (witness) of plots having suffered no fire during the chosen period constitutes another component to serve as a comparison. It has chosen five (05) stations based on the

frequency of fires and fire (1990-2009) (modality I. 2009 , modality II. 2007, modality III. 2003, mode IV. 1998, mode T. witness).

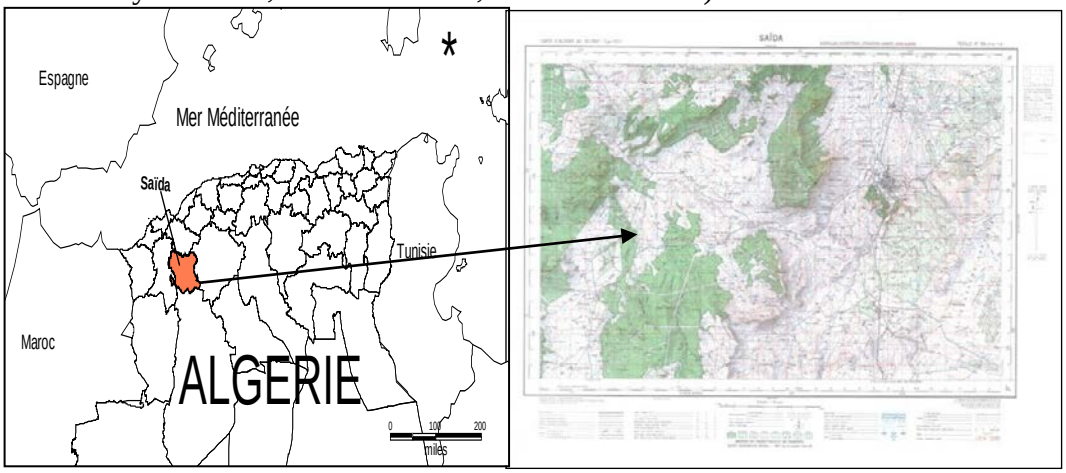

Figure 1: Location of the study area

Method study of vegetation

Sampling: In the proposed study, completed 25 vegetation surveys (5 surveys by modality of fire and for the control station).

The floristic surveys were conducted according to the method of Braun-Blanquet et al. (1964) which consists in assigning to plant species encountered, indices of abundance – dominance, set apart from the coefficient of sociability that has not taken into account in our study.

From this scale, several authors have established a transformation of the coefficients of abundance – dominance (AD) to quantitative values, corresponding to recoveries (r) means median classes in general and our choice is focused on that proposed by Dufrêne (1998,2003).

Each floristic survey is accompanied by a statement of the conditions site namely altitude, exposure and slope. From this inventory our species has been classified on the basis of their regeneration strategies.

Surveys were made according to a subjective sampling, field plots of his statements is chosen according to two levels of perception:

• A first level according to the acreage burned in accordance with the minimum air (400 m²) so that all species are represented in each station.

•A second level according to the ecological homogeneity of each station in terms of exposure, light and topography.

Data processing and statistical analysis

Changes in the structure of vegetation during the post-fire chronosequence were analyzed by a measure of wealth specific (S) and by regeneration strategy that corresponds to the total number of taxa found

during an inventory of each modality of time since fire and by the calculations of the Shannon - Wiener 1949 diversity indices (H') :

$$H' = -\sum_{i=1}^{S} p_i \log_2 p_i$$

H': Shannon biodiversity index

S : total number of species;

i : a kind of study environment

p_i: Proportion of a species i compared to the total number of species (S) in the middle of study (or specific richness of the environment, or proportional abundance or percentage of special significance of the species), which is calculated as follows:

$$p(i) = n_i/N$$

where is the number of individuals for the species i and N is the total (individuals of all species).

Results and discussions

Regeneration strategy post-incendies by rejection of strain

Many dominant species of Mediterranean ecosystems after fire resumed the vegetatively propagated (Lioret, 1998). The dynamics of "rejetonnage" of the stem after the passage of fire has been studied by comparison of the rates of recovery of the species who reject strains present by mode of fire.

Four years after the passage of fire, were observed in burned plots the highest recovery rate of plants that regenerate by Stump Sprouts (figure 2). On the other hand, on the plots of other types there is a degree of uniformity of the recovery rate. However, the average of this rate of plot burned four years remains higher than that of the releases of other plots.

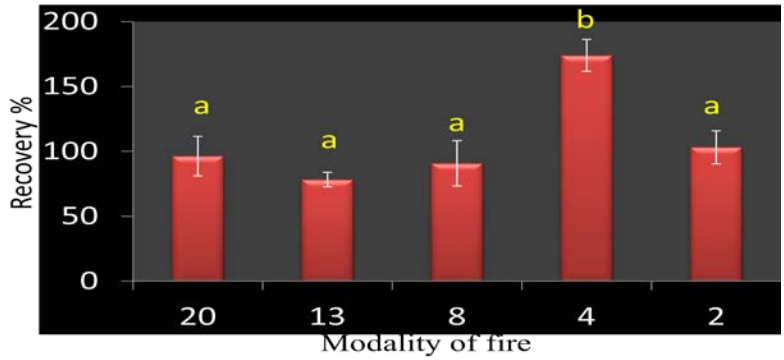

Figure 2 : Evolution of the recovery of the species which regenerate by rejection of strain (R) after fire different types of fire (H = 16.07 p < 0, 001). Identical lowercase letters indicate the absence of significant difference between mean (± standard deviation).

Fire to an inductive effect on the emission of the Stump Sprouts in the plot burned four years (the number of discharges increasing strongly in such plants) that corroborates the hypothesis of a trip due to the passage of fire and a hormonal phenomenon.

The species who reject strains present in this type are mainly Quercus, Arbutus, Juniperus, Phillyrea, Pistacia (table 1) which are more and more replaced by the chamephytes adapted to fire or by a flora ephemeral at base of therophytes that not protecting any soil exposed to erosion.

The adaptation of the oak fire induced a thick bark, the presence of a pivot, the ability to produce strong releases, resistance to decay after injuries and the possibility of benefiting from germination beds created by fire (Abrams, 1997).

The type of regeneration strategy promoted after a fire is not yet clear, Fernandez-Santos, 2004, Bekdouche, 2010, Crosti, 2006 show that there is a phylogenetic and biogeographic model in the behavior of the species during regeneration after fire.

Vegetative regeneration by emission of Stump Sprouts is more common in the young trees, and less than 50% of the older trees over 125 years are capable of releases of strain (Burns and Honkala 1990). In the first year after the passage of a fire, release of strain settled at the foot of dead trees. It is not uncommon to see show 6 or 7 releases by strain (Coates and Haeussler 1986 in Sims et al. 1990).However, their survival rate is generally low. According to Burns and Honkala (1990), less than 27% of releases survive after 2 years. One of the important causes of mortality would be grazing by animals.

Regeneration strategy post-incendies by seeding

There are species that have not the ability to survive fire, their regeneration is based entirely on the germination of seeds (Ferrandis, 1999). The germination of the seeds is the main mechanism adopted by the majority of the species list in our plots with almost 67%. Indeed many authors have shown that the primary mode of regeneration after disturbance is sexually.

The statistical test shows us that there is a significant difference ($H = 20.63$ $p < 0, 001$) between different types of fire 20 years, 8 years and 4 years are different from 2 years and 13 years. The type 4 years has the highest rate of recovery of the species which regenerate by semi, however the 2 years type has a low rate of recovery (figure 3) this may be due to the effect of the fire that stimulates these plants.

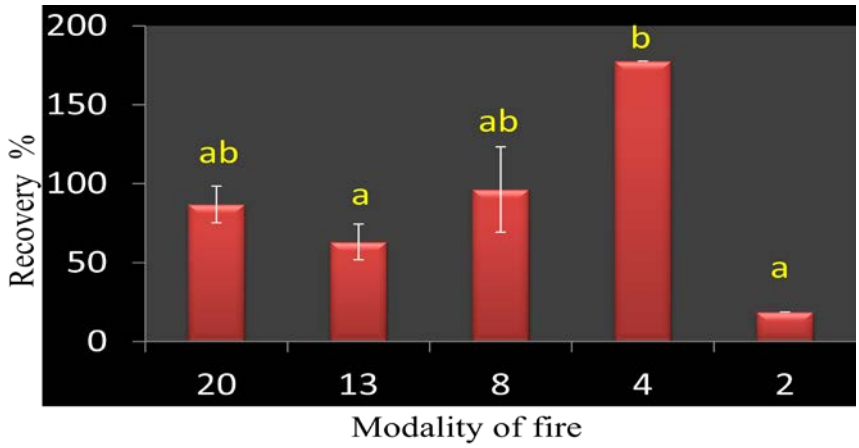

Figure 3: Evolution of the recovery of the species which regenerate by semi (M) after fire different types of fire (H = 20.63 p < 0, 001). Identical lowercase letters indicate the absence of significant difference between mean (± standard deviation).

In fact, smoke from fuel stimulate the germination of the seed up to a maximum and then a decrease is observed due to the high levels or duration of exposure that inhibit germination (Light, 2002) or becomes downright lethal (Keeley, 2005, Bekdouche, 2010).

The main species that regenerates by semi and presents in the overstory is Pinus halepensis Mill. (table I). Vennetier (2003) shows in these works on Aleppo Pine that the heat from the flames promotes the opening of cones: seed begin to fall a few hours after the fire, with a peak between the 2nd and the 4th day to stop after 6 to 8 days.

The amount of this seed rain is independent of the power of fire. The cones are resistant to the most violent fires, their scales can be calcined outside while the seeds are affected. More than 90% of them fall around the seed within a radius of 10 m.

It may be also that the frequency of occurrence of seedlings and their survival depend on residual organic matter thickness after fire and the amount of water present. Seedlings are particularly sensitive during the first years of growth to water deficit, which represents their main cause of death (Sirois 1993, Thomas and Wein 1985)

It seems also that the characteristics of the bed of germinating immediately after fire (modality 2 years) are also favourable to the installation of regeneration. The environment is often too rich in toxic minerals from burning to the ground. Burned soil covered with black ash could also release heat during periods of sunshine as it may inhibit the germination of seeds (Sirois 1993).

Aleppo Pine is a particularly well adapted to fire, because of the presence in the trees of the persistent cones. The success of regeneration after fire is dependent on the presence of trees from seeds viable and non-parasitized on the burned site. Finally, the fire creates, by eliminating any vegetation competitor, an environment of favorable installation for this species. Our results clearly show that the Aleppo Pine is a species remarkably adapted to fire because it has these two characteristics: fire resistance and regeneration.

Regeneration strategy post-incendies by rejection of strain and seedlings

The percentage of plants that regenerate by rejection of strain and semi (figure 4) inventoried in the plots of all types of fire is relatively low in the range 10% and represented mainly by the following families: Cupressaceae and Fabaceae, Lamiaceae (Table I).

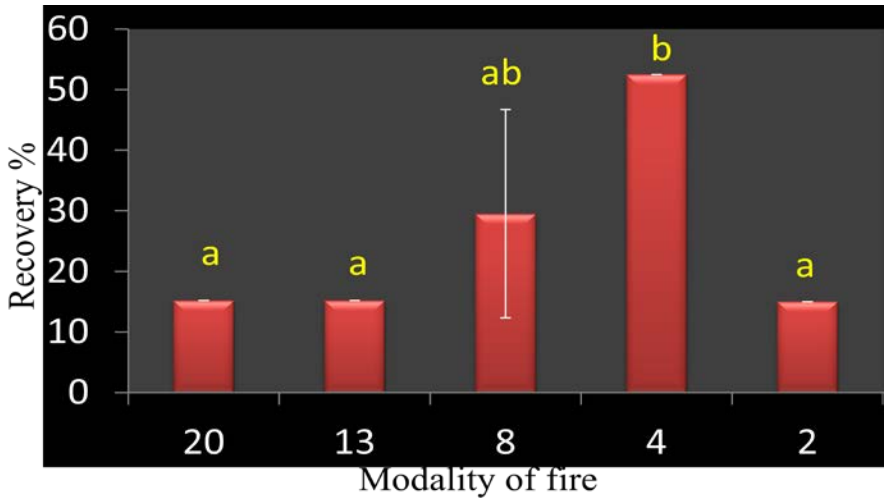

Figure 4: Evolution of the recovery of the species which regenerate by rejection of strain and semi (RS) after fire different types of fire (H = 17.61, p < 0, 001). Identical lowercase letters indicate the absence of significant difference between mean (± standard deviation).

The same results as the previous test with a predominance of type 4 years species are found. Apparently this mode of regeneration would be stimulated also by the fires. In plots, four years, are required to have a peak of regeneration of these families.

It is clear that the strategy by semi is more advantageous because it does not require the production of a whole organism, but cannot be applied when the vital organs (including the cambium) are not affected. Wright and Bailey (1982) consider that the exposure of the cambium during one minute at a temperature of 60 ° C is lethal

It is the intensity of damage and stress-related disturbance that will determine the strategy. It is extremely likely that the morphology of the tree may intervene in the determinism of the strategy by allowing the tree to resist disturbance: stress and damage seem less felt by large individuals. It is then that trade-offs in the allocation of resources come into play.

Arborescente species found here is the Tetraclinis articulata (Vahl.), it is a Monoecious species which rarely exceeds 6 to 8 m high and 0.30 m in diameter on average.

The opening of the cones of this species, which remains as for many species conditioned by heat, takes place at the end of the summer. The production of seeds of this species is relatively good or even very good (100 000 seeds/kg) and the problem of its regeneration does not appear to be constrained by the quantity of seeds produced (Hadjadj, 2009).However, seeds stored in the dark and dry atmosphere keep a good germination capacity up to 20 months. The dissemination of these seeds is still quite limited and the biggest seed are found at the foot of unlike the much more expansionary Aleppo pine tree (Acherar, 1981). Furthermore, we recall that the Tetraclinis articulata is one of rare conifers to reject ethnic and until a very advanced age, 400 years approximately by Boudy (1952). It is what gives the appearance of coppice stands and has undoubtedly contributed significantly to its maintenance in North African forested massifs. The influence of grazing is very harmful to seedlings, which makes natural regeneration by seed random and very low after a fire. While regeneration by vegetative way is important, it is one of rare conifers able to reject strains.

Table I. list of plant species on the basis of their regeneration strategy.

Species (reg stg : R)	**Species (reg stg : S)**	**Species (reg stg : R and S)**
1. *Quercus rotundifolia* Lam	1. *Pinus halepensis* Mill	1. *Tetraclinis articulata* (Vahl .)
2. *Olea europea* L	2. *Rosmarinus tournefortii*	2. *Génista quadriflora*
3. *Arbutus unedo* L	3. *Cistus ladaniferus*	3. *Calycotome spinosa L*
4. *Quercus coccifera* L.	4. *Cistus libanotis* L	4. *Cistus salviifolius* L
5. *Pistacia lentiscus* L.	5. *Cistus villosus*	5. *Thymus algériensis* Boiss.et Reut.
6. *Pistacia terebinthus* L	6. *Globularia alypum*	
7. *Juniperus oxycedrus* L.	7. *Asphodelus microcarpus* SALZM	
8. *Phillyrea angustifolia*	8. *Erodium botrys* L	
9. *Stipa tenacissima* L	9. *Linum strictum* L	
10. *Chamaerops humilis* L.	10. *Avena clauda DUR*	
11. *Ampelodesma mauritanica* (Poir.)	11. *Lolium perenne* L	
	12. *Anthericum liliago* L.	
	13. *Ornithogalum narbonense* L	

14. Reseda alba L
15. Lavandula stoechas L.
16. Hordeum murinum L
17. Aegilops triaristata WILD
18. *Scilla peruviana* L
19. Urginea fugax MORIS
20. Muscari racemosum L
21. *Teucrium pseudochamaepitys* L
22. *Thymus ciliatus* DESF
23. Thymus fontanesii
24. Anagallis monelli
25. Thapsia garganica L
26. Ferula communis L
27. *Ophrys speculum* link
28. Papaver rhoeas L
29. *Fumana thymifolia* L
30. Helianthemum helianthemoides (Desf.)
31. *Helianthemum pilosum* L
32. Dactylis glomerata L.

Reg stg : The postfire regeneration strategy ; **R :** Rejection of strain ; **S** : Regeneration by seed

Conclusion

The lights are among the most important environmental problems in the countries of the Mediterranean basin. This is particularly true in the forested regions of the semi arid areas where it can plant species that remains is the last barrier to desertification and are in continual struggle against climate change and the recurrence of fires.

It appears from this study that the forest of Fenouane, which enjoys a special climate and a very dry soil can plant species, it has surveyed 48 total. In such conditions, the post-fire vegetation depends in large part of the seed bank which lies in the soil and their capacity arose; on all of the surveyed vegetation the majority either 32 species have a semi regeneration strategy.

Indeed, colonization of burned areas depends in large part on the seed bank and this can be affected by the severity of the fire and its repetition as it demonstrated several authors (Moravec, 1990, Whelan, 1995, Herranz , 1998).

Gold in these areas in addition to climatic and edaphic aridity he y' more and more fire over very short periods that leaves may chance to seed

that contains ground sprouted the following year and it partly explains the few plant species that continues to survive in these areas

Our results shows that the rate of germination by semi is maximally 4 years after a fire at the level of the state herb which has all species that appear of the first years after the fire. Species of which the majority are foreign to the community, dominate in this stratum.

However we note that only 11 species on 48 have a regeneration by rejection strategy and are found mainly in wooded and shrubby stratum, this shows the State of degradation in which is located the two strata and the disappearance of several species including: *Quercus rotundifolia* Lam, *Olea europea* L, *Arbutus unedo* L, *Quercus coccifera* l. very abundant in these areas once and that happens more to be regenerated due to the recurrence of fires on periods very short and probably also because of climate change and loss of soil nutrients.

These results shows that it is not only important fire which is responsible for the destruction of plant species but that the climatic conditions in semi-arid areas plays a role in the selection of species that will stay in these very vulnerable woodlands struggling to be regenerated and if we do nothing saved for these some relics will be a few years at a first stage of desertification of these areas in this case the total disappearance of the species it contains.

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